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Comparison of trauma patients with typical - atypical rib fractures

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Abstract

Aim: Morphologically, ribs are classified as typical or atypical. While typical ribs are the 3-9th ribs, atypical ribs are the 1st, 2nd, and 10-12th ribs. There are several studies on rib fractures. However, no specific studies and comparisons have been reported on rib fractures according to the calcifications of the ribs. In our study, we aimed to share the results of trauma patients with typical-atypical rib fractures.

Material and Methods: According to the morphological features of the broken ribs, the patients were divided into two groups: Group 1 (patients with typical rib fractures; 322) and Group 2 (patients with atypical rib fractures; 160). The results were evaluated. $p<0.05$ was considered significant.

Results: According to the demographic distribution of the patients, the male gender was more significant in Group 1 compared to Group 2 ($p<0.05$). However, there was no significant difference between the groups in terms of the number of patients who died and localization ($p>0.05$). In terms of concomitant pathologies, pneumomediastinum, contusion, and flail chest development were statistically significant in Group 1 patients compared to Group 2 ($p<0.05$). The mean CWIS of Group 1 was found to be significant compared to Group 2 ($p<0.05$).

Discussion: According to our study, in terms of concomitant pathologies, pneumomediastinum, contusion, and flail chest development in typical rib fractures were more common in patients with atypical rib fractures. Although trauma scores were generally higher in Group 2 than in Group 1, they were not significant in patients with typical-atypical rib fractures except for CWIS. Especially in patients with a high CWIS, surgical treatment can be performed depending on the condition of the concomitant organ injuries.

Keywords

Ribs, Fractures, Thorax, Trauma

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Introduction

A rib consists of a caput, collum, tubercle, and corpus. The first 7 ribs are called true ribs and fuse with both the vertebrae and the sternum, while the 8-9-10-11-12th ribs are called false ribs. The cartilage parts of the 8-9-10th ribs combine with each other and adhere to the cartilage of the 7th rib anteriorly, whereas they fuse with the vertebrae posteriorly. The 11th and 12th ribs are called the vertebral or floating ribs [1]. Morphologically, ribs are classified as typical or atypical. While typical ribs are the 3-9th ribs, atypical ribs are the 1st, 2nd, and 10-12th ribs [2]. Rib fractures are seen in 35-40% of thoracic traumas [3]. Fractures are common between the 4-9th ribs. The 1st and 2nd rib fractures are traumas that require high energy. Subclavian vascular injuries are seen with 1st and 2nd rib fractures. Intrathoracic injuries are more common in fractures between the 3-7th ribs, while intra-abdominal and spinal injuries as well as intrathoracic injuries are seen in fractures between the 8-12th ribs [4, 5, 6].

There are several studies on rib fractures. These studies reported factors affecting mortality and morbidity. However, no specific studies and comparisons have been reported on rib fractures according to the calcifications of the ribs. In our study, we aimed to share the results of trauma patients with typical-atypical rib fractures.

Material and Methods

Patients

Ethics committee approval was received for the study (approval date and number: 23.09.2021/10-14). A total of 482 patients who were followed up and treated for post-traumatic typical or atypical rib fractures between 2015 and 2021 were included in the study.

Procedures

According to the morphological features of the broken ribs, the patients were divided into two groups: Group 1 (patients with typical rib fractures; 322) and Group 2 (patients with atypical rib fractures; 160). Age, gender, symptoms, localization of fractures, radiological findings, diagnosis and treatment methods, complications, concomitant pathology and organ injuries, mean number of fractures, rib fractures score (RFS), chest wall injury score (CWIS), chest trauma score (CTS), thoracic trauma severity score (TTSS), injury severity score (ISS), and mortality and morbidity rates were recorded.

Statistics

IBM SPSS Statistics Base 22.0 program (IBM Corporation, Armonk, NY, USA) was used for data analysis. Continuous variables were expressed as mean ± standard deviation, while categorical variables were explained as number-ratio. Homogeneity analysis of variances was conducted with Levene's test ($p>0.05$). The Shapiro-Wilk test was used to evaluate the normal distribution ($p>0.05$). Results were evaluated with the Kruskal-Wallis, analysis of variance, and Mann-Whitney-U tests. $p<0.05$ was considered significant.

Ethical Approval

Ethics Committee approval for the study was obtained.

Results

The most common complaints of the patients were chest pain and shortness of breath. The main diagnostic methods were physical examination findings, chest X-ray, and mostly computed tomography of the thorax (Figure 1).

Table 1. Demographic distribution of patients with rib fractures.

Variables	Total; 482	Group 1; 322	Group 2; 160	P value*
Male	445, 92%	293, %91	152, 95%	< 0.00001
Female	37, 8%	29, %9	8, 5%	
Average age	56,55±18,17	56,30±18,30	57,06±17,96	
Dead number	75	43, 13%	21, 13%	1
Right hemithorax	221, 46%	145, 45%	76, 48%	0.9211
Left hemithorax	226, 47%	147, 46%	79, 49%	
Bilateral	35, 7%	30, %9	5, 3%	

%; Percentage, *; Fisher exact test

Table 2. Concomitant pathologies accompanying rib fractures.

Concomitant pathology	Total; 482	Group 1; 322	Group 2; 160	P value*
Pneumomediastinum	7, 1%	2, 1%	5, 3%	0.0433
Hemothorax	29, 6%	16, 5%	13, 8%	0.5783
Pneumothorax	34, 7%	21, 7%	13, 8%	0.5718
Contusion	45, 9%	24, 7%	21, 13%	0.0476
Flail chest	13, 3%	5, 2%	8, 5%	0.0368
Clavicle fracture	20, 4%	13, 4%	7, 4%	0.8138
Scapula fracture	13, 3%	6, 2%	7, 4%	0.136
Sternum fracture	34, 7%	22, 7%	12, 8%	0.8506
Vertebra fracture	12, 2%	7, 2%	5, 3%	0.5439
Vertebra + scapula fracture	9, 2%	5, 2%	4, 2%	0.488
Kidney injury	1, 0.2%	0	1, 1%	0.332
Spleen + kidney injury	1, 0.2%	0	1, 1%	0.332
Liver injury	5, 1%	3, 1%	2, 1%	0.6687
Liver + kidney injury	2, 0.4%	2, 1%	0	1
Liver + kidney + spleen injury	1, 0.2%	1, 0,31%	0	1

%; Percentage, *; Fisher exact test

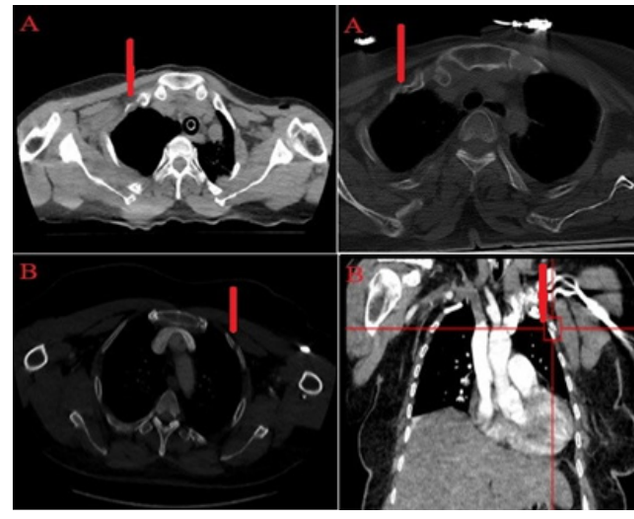

Figure 1. Figure 1A: Mediastinal and bone window images of first rib fracture.
Figure 1B: Bone and Mediastinal window images of 2nd rib fracture.

Table 3. Comparison of the mean score values of the groups (between groups 1, 2, 3).

Average scores	Total	Group 1	Group 2	The z-score	p-value *
Average RF	3,02 ± 2,92	3,01 ± 2,86	3,05 ± 3,04	0.19132	0.8493
Average RFS	4,84 ± 4,71	4,95 ± 4,82	4,61 ± 4,49	0,5295	0.59612
Average CWIS	1,68 ± 0,79	1,61 ± 0,73	1,82 ± 0,90	-19.885	0.0466
Average CTS	5,01 ± 1,46	4,95 ± 1,43	5,15 ± 1,53	-1,35136	0.17702
Average TTSS	6,58 ± 2,20	6,57 ± 2,22	6,62 ± 2,17	-0.44687	0.65272
Average ISS	7,90 ± 8,64	7,27 ± 8,15	9,16 ± 9,45	-17.142	0.08726

RF; Rib fracture, RFS; Rib Fracture Score, CWIS; Chest Wall Injury Score, CTS; Chest Trauma Score, TTSS; Thoracic Trauma Severity Score, ISS; Injury Severity Score, *; Chi-Square test

According to the demographic distribution of the patients, male gender was more significant in Group 1 compared to Group 2 ($p<0.05$). However, there was no significant difference between the groups in terms of the number of patients who died and localization ($p>0.05$) (Table 1).

In terms of concomitant pathologies, pneumomediastinum, contusion, and flail chest development were statistically significant in Group 1 patients compared to Group 2 ($p<0.05$). There was no statistically significant difference between the groups in terms of concomitant organ injuries ($p>0.05$) (Table 2).

The mean CWIS of Group 1 was found to be significant compared to Group 2 ($p<0.05$) when the groups were evaluated in terms of the mean number of fractures, RFS, CWIS, CTS, TTSS, and ISS ($p<0.05$) (Table 3).

In treatment, it was observed that 60 (12%) patients underwent tube thoracostomy, 10 (2%) patients underwent thoracotomy (7 bleeding control + hematoma evacuation, 3 primary diaphragmatic repair), and 2 (0.41%) underwent chest wall reconstruction. In addition, it was determined that 10 (2%) of the flail chest patients were followed in the intensive care unit, 3 (1%) had fixation + intensive care follow-up, and all of the patients with pneumomediastinum got fiberoptic bronchoscopy + esophageal passage graphy and endoscopy.

The most common morbidities in patients were wound infection (n: 103, 21%), pneumonia (n: 42, 9%), and atelectasis (n: 52, 11%). The mean hospital stay was 7 ± 5.2 days.

Discussion

The most common condition following blunt thoracic trauma is rib fractures with a rate of 50% [7]. Morphologically, ribs are classified as typical or atypical. Typical ribs (ribs 3-9) consist of a head, neck, tubercle, and body. The head parts articulate with the lower part of the corresponding vertebral body and the upper part of the next vertebra, forming two separate articular surfaces. The tubercle, on the other hand, is the junction of the neck and body and combines with the transverse process of the numerically corresponding vertebra to form the costotransverse joint. The body part is curved and contains a groove in the inferomedial region, through which intercostal vessels and nerves pass. They articulate anteriorly with the sternum [8]. The 1st, 2nd, 10th, 11th, and 12th ribs are atypical. At the head of the first rib, there is a single face that articulates with the Th1 vertebral body. Its upper surface has two grooves for the subclavian vessels. The main atypical feature of the second rib is the superiorly located tuberosity, from which the serratus anterior muscle partially originates. The 10th, 11th, and 12th ribs have only one articular surface in their heads. In addition, the 11th and 12th ribs lack neck and tubercles [2]. In our study, we aimed to evaluate the outcomes of trauma patients with these rib fractures with different morphological features.

In a study conducted with 214 patients with rib fractures, the mean age was reported to be 51.50 years, and a correlation was found between the increasing number of broken ribs with mortality and morbidity independent of concomitant injuries [9]. In our study, we found the mean age as 56.55 ± 18.17 (group 1; 56.30 ± 18.30, group 2; 57.06 ± 17.96) and mortality rate as 16% (group 1; 43, 13%, group 2; 21, 13%). There was no significant difference in terms of mortality between the groups ($p>0.05$).

In another study, rib fractures were reported to be 69% in men and 53% in women, and the male gender was significant. In the same study, it was also stated that fractures occur more frequently in the 5-8th ribs, less frequently in the upper ribs, and least in the anterior parts [10]. In our study, while the male gender was significant in Group 1 patients compared to Group 2, localization was not significant between groups.

The main diagnostic methods in rib fractures are physical examination, posteroanterior chest X-ray, and, rarely, computed tomography of the thorax. Pleurotic chest pain and local tenderness guide the examination. The pain increases with coughing and breathing. Due to severe pain, patients cannot secrete. Atelectasis occurs and patients face the danger of hypoxia and metabolic acidosis due to pulmonary shunts. Rib fractures may not be seen up to 50% in chest X-ray, lateral rib fractures may be hidden by rib lines when there is no obvious separation. Lower rib fractures can be observed on thoracolumbar radiographs. Intra-abdominal hemorrhage should be evaluated in lower rib fractures [11]. The main diagnostic methods in our patients were chest X-ray and computed tomography of the thorax. This is due to the need for tomography for the evaluation of other systems in multi-trauma patients.

Early complications are contusion, pneumothorax, and hemothorax, while late complications are atelectasis and pneumonia in patients with thoracic trauma with rib fractures. The average blood loss from a broken rib is 100-150 milliliters. Broken rib ends may lacerate the intercostal muscles and develop massive hemothorax. The prognosis depends on the age of the patient, the number of broken ribs, and the condition of concomitant injuries. Fractures of the first and second ribs require high energy, and subclavian vascular injuries may occur in these fractures. There may be minor aorta and innominate artery injuries and tracheobronchial injuries. Intra-abdominal organs and spinal injuries should not be ignored in intercostal fractures between 9-12. Liver and spleen injuries may occur, especially in fractures of the 10th and 11th ribs [11, 12, 13]. In our study, the number of fractures in typical ribs was higher than in atypical ribs. In terms of concomitant pathologies, pneumomediastinum, contusion, and flail chest development were statistically significant in Group 1 patients compared to Group 2 ($p<0.05$). There was no statistically significant

difference between the groups in terms of concomitant organ injuries (p>0.05). No serious intracranial injuries were observed in any of the patients, except for major vessel injuries and simple facial injuries. We think that this is due to the fact that patients with intracranial injuries are followed up by the relevant clinics or directly to the intensive care unit.

The Rib fractures score (RFS) is used to determine the risk ratio of complications that may develop in rib fractures. With this method it is possible to decide whether the patient needs care or not. Moreover, it has been reported that optimal analgesic treatment for mobilization, deep breathing exercises, coughing, and respiratory physiotherapy can be provided, and patients with an RFS above 7 points should be referred to pain relief units (algology or anesthesia) [14]. In our study, the RFS values were below 7, and there was no statistically significant difference between the groups (p>0.05).

Chest Wall Injury Scale (CWIS) is a scoring system that helps to determine the treatment method according to the condition of the injury in the chest wall. Taylor et al. reported that this scale system is a guide for the decision of surgical intervention and that mortality and morbidity increase with the elevation in scoring [15]. In our study, the mean CWIS value in Group 1 was statistically significant compared to Group 2 (p<0.05). As it is especially high in patients undergoing reconstruction and fixation, the elevation of CWIS may guide surgical treatment. However, despite surgery, the mortality rate varies according to concomitant pathology and organ injuries.

Chest trauma score (CTS) is a scoring method based on the patient's age, number of broken ribs, location of the fracture, and lung contusion. Chen et al. reported increased morbidity and mortality in patients with thoracic trauma with a CTS greater than 5 [16]. In our study, although CTS values were higher in Group 2 patients than in Group 1, there was no statistically significant difference between the groups (p>0.05).

The Thoracic Trauma Severity Score (TTSS) is a scoring system with a score between 0-25, covering patient age and findings such as PaO2/FIO2 ratio, pulmonary contusion, pleural pathology, and rib fracture. This system is closely associated with mortality and morbidity. It has been reported that TTSS is a very significant scoring system for mortality and morbidity [17, 18]. In our study, although TTSS values in Group 2 patients were higher than in Group 1, there was no statistically significant difference between the groups (p>0.05).

The Injury severity score (ISS) provides numerical calculation and identification of the total severity of injuries in persons with multiple body injuries. It is associated with mortality, morbidity, and length of hospital stay. If the ISS is greater than 16, major trauma is present. All injuries should be identified when calculating [19]. In our study, although ISS values were higher in Group 2 patients compared to Group 1, no statistically significant difference was found between the groups (p>0.05).

The main approach in the treatment of rib fractures is pain control and breathing exercise. Hypoventilation due to pain predisposes to secretion retention, atelectasis, and infection. Therefore, pain should be prevented and respiratory physiotherapy should be performed. Young cases and patients without complications can be followed up on an outpatient basis. However, it is essential that elderly patients be observed in the hospital and have good pain treatment. Although the treatment of rib fractures is conservative, complications caused by broken ends may require surgical intervention. In these cases, the platinum application is an important method that facilitates stabilization [20]. In our study, 60 (12%) patients underwent tube thoracostomy, 10 (2%) patients underwent thoracotomy (7 bleeding control+hematoma evacuation, 3 primary diaphragmatic repair), and 2 (0.41%) patients underwent chest wall reconstruction. In addition, it was determined that 10 (2%) of the flail chest patients were followed in the intensive care unit, 3 (1%) of them had fixation+intensive care follow-up, and all of the patients with pneumomediastinum underwent fiberoptic bronchoscopy+esophageal passage graphy and endoscopy.

Conclusion

According to our study, there was no difference between the two groups in terms of mortality in trauma patients with typical or atypical rib fractures. However, in terms of concomitant pathologies, pneumomediastinum, contusion, and flail chest development in typical rib fractures were more common in patients with atypical rib fractures. Although trauma scores were generally higher in Group 2 than in Group 1, they were not significant in patients with typical-atypical rib fractures except for CWIS. In treatment, patients should be monitored, and oxygen saturation, arterial blood pressure, cardiac rhythm, and arterial blood gas should be monitored. In addition, pain control and respiratory physiotherapy should be provided. While the primary treatment method in patients with intrathoracic complications is simple tube thoracostomy, larger surgical interventions can be performed when necessary, despite high mortality. Especially in patients with high CWIS, surgical treatment can be performed depending on the condition of the concomitant organ injuries.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

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